Androscoggin River
Alternative Analysis for TMDL
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Executive Summary

This study focuses on Gulf Island Pond, which is a large impoundment on the Androscoggin River that extends for 14 miles from Lewiston to Turner. A four-mile segment upstream of Gulf Island dam is on Maine's 303d non-attainment list of bodies of water that do not meet relevant water quality standards. This segment does not meet the designated use of aquatic life support because it fails to meet (1.) class C dissolved oxygen criteria and (2.) the designated use of water contact recreation due to yearly occurrence of algae blooms. Federal law requires Maine to undertake a Total Maximum Daily Load (TMDL) (plan for cleaning up segment to required water quality standards). A TMDL is a plan specifying how pollutant inputs will be reduced in order to comply with water quality standards. This is typically determined mathematically with a water quality model. A water quality model was developed by DEP using data collected both historically and in the summer of 2000. The Androscoggin River Modeling Report and Alternative Analysis (June 2002, MDEP, Mitnik, Paul, P.E.) summarizes the modeling analysis and alternatives investigated to improve river water quality to class C standards.

Upstream from Gulf Island Pond, three paper mill discharges and five municipal point sources discharges enter the river from Berlin, NH to Livermore Falls, ME. The modeling report has determined that point source discharges are primarily responsible for water quality problems in Gulf Island. The large size of Gulf Island Pond (length of 14 miles and maximum depth of 80 feet) also contributes to the problem by providing an environment which has a poor capacity to assimilate point source waste without depleting dissolved oxygen to unacceptable levels. Maine law requires that the minimum levels of dissolved oxygen be maintained to support fish and other aquatic life.

The Androscoggin River has a long history of continuing efforts by the DEP, the paper mills and others to improve water quality. A low point was reached in the 1960's when it was recognized as one of the ten most polluted rivers nationally. Since 1960, point source discharges have been reduced by more than 90%. Despite the reductions, waste that had accumulated on the bottom of Gulf Island prevented attainment of dissolved oxygen criteria in deeper portions of the pond. As a result, in 1993 an oxygen diffuser was installed five miles up from Gulf Island dam as a way to artificially enhance the dissolved oxygen.

The oxygen diffuser is called the Gulf Island Pond Oxygenation Project (GIPOP). The three paper mills and the electric utility company that operates the hydropower facility at the dam share in the operation and cost of operating GIPOP.

Non-compliance of dissolved oxygen criteria persists in deeper areas of the pond representing about 20% of the total pond volume, despite all the mentioned cleanup efforts. The non-attainment of dissolved oxygen in the deeper areas of Gulf Island Pond and some other impoundments statewide has prompted DEP to consider criteria specific to impoundments. The Department has proposed legislation that determines how compliance with dissolved oxygen criteria will measured in riverine impoundments. This legislation proposes that dissolved oxygen will not be measured for compliance in poorly mixed bottom areas of impoundments, areas where mixing is inhibited due to thermal

stratification or natural topographic features. It is in these poorly mixed areas that compliance of dissolved oxygen is difficult and not expected, due to DEP's experience in lake situations. While the various abatement alternatives investigated for cleanup can be effective in well-mixed areas, they are usually not effective in poorly mixed areas.

Without the proposed legislation, the only probable path forward would be a Use Attainability Analysis (UAA). A Use Attainability Analysis (UAA) is a structured scientific assessment of the physical, chemical, biological, and economic factors affecting the attainment of designated uses of a water body. A UAA is undertaken in situations, when, after considering all available and reasonable options, existing water quality standards are unattainable or not affordable. The evaluation of the cost of all possible alternatives of river cleanup and the water quality that results is necessary to meet the requirements of state and federal law for a UAA. The eventual goal of a UAA is to have the best water quality possible within affordable constraints. The criteria set in class C are the minimum needed to support the fishable and swimmable goals of the Clean Water Act. As a result of a UAA, it might be necessary to establish numerical criteria for dissolved oxygen that are less stringent than existing class C criteria. In the case of Gulf Island Pond, this would result in some loss of aquatic life use. This would also be the first time that a UAA would allow a Maine water body to not meet the minimum class C criteria.

In this report, additional alternatives are investigated with a water quality model for the TMDL. All alternatives (except dam removal) assume the current oxygen injection into the pond will continue.

1. No Action – No changes to waste discharge licenses of point sources.
2. Status Quo – Reduce allowable point source pollutant inputs to actual discharge levels.
3. Status Quo + Nutrient Reductions - Reduce allowable point source pollutant inputs to actual discharge levels. Require additional phosphorus reductions.
4. Alter or Eliminate Impounded Waters - Dam removal or reduction of dam height
5. Reduce or Eliminate Point Sources – Investigate greater reductions than #3
6. Status Quo with Non-point Source Reductions - Use solely NPS reductions
7. Additional Point Source Reductions and Additional Oxygen Injection - #3 with additional oxygen injection.

The extent of non-attainment of class C water quality standards that are predicted by the water quality model are as follows:

Alternative	Without Proposed Impoundment Legislation			With Proposed Impoundment Legislation			Algae Bloom Threshold (Chl-a 8 ppb)
	Length of DO Non-attainment	% DO non-attainment of Pond Vol	UAA Required? Y / N	Length of DO Non-attainment	% DO non-attainment of Pond Vol	UAA Required? Y / N	
1	38 mi	72%	Y	38 mi	71%	Y	2.4 X
2	4 mi	20%	Y	4 mi	19%	Y	2.1 X
3	4 mi	9%	Y	4 mi	8%	Y	< Threshold
4	0 mi	0%	N	0 mi	0%	N	< Threshold
5	1 mi	1%	Y	0 mi	0%	N	< Threshold
6	4 mi	11%	Y	4 mi	10%	Y	2 X
7	1 mi	1%	Y	0 mi	0%	N	< Threshold

Assuming the proposed impoundment legislation passes, options 4, 5, and 7 all meet class C water quality standards. Options 1,2,3 and 6 would not meet water quality standards and would require a Use Attainability Analysis (UAA). Alternatives 4 and 5 are assumed to be impractical or economically unaffordable. The alternative preferred by MDEP (alternative 7) is as follows:

- BOD – Limit BOD entering the pond to no greater than current levels. This requires a net reduction in the total current licensed levels from all of the paper mills of 46% and 40% for a monthly and weekly average, respectively.
- TSS - Limit TSS entering the pond to no greater than current levels. This requires a net reduction in the total current licensed levels from all of the paper mills of 64% for a monthly average.
- Total Phosphorus – Reduce TP entering the pond by 60%. This requires a net reduction of point source TP inputs of 67%.
- Non-point Sources of BOD / TSS / TP – limit to no greater than current levels
- Oxygen Injection – Require oxygen injection of GIPOP1 = 35000 ppd. and GIPOP2 = 70000 ppd., respectively, at Upper and Lower Narrows. This is only a 14% increase from current oxygen injection (GIPOP1) but requires an additional injection point (GIPOP2).

This alternative results in the highest amount of compliance with water quality standards without removing the dam.

The final allocation for each point source is not specified in this report. The DEP is encouraging point source dischargers to determine the most economic way of achieving water quality standards through a negotiated agreement. This might include an innovative system for trading pollution credits among the dischargers. As a starting point, DEP has offered four different methods for allocating point source inputs (actual treatment, equal treatment, equal % reductions, and receiving water impact) were investigated. The individual TMDL for each point source will depend upon the allocation method chosen.

Cost estimates for alternative 7 have been provided. These estimates use an equal treatment allocation, assuming that mill and municipal plants will be required to treat to comparable levels. The costs might be reduced if less expensive source reductions through pollutant prevention are implemented rather than end-of-pipe treatment. The cost estimate is as follows:

Summary of Additional Costs

Annual Costs	Cost @ Actual Flow	Cost @ Licensed Flows
TP Treatment to 0.25 ppm for 3 Paper Mills	915,000	1,021,000
TP Treatment to 1.0 ppm for 3 Municipal WWTP's	197,000	263,000
15% Increase of Oxygen Injection	$100,000	
Total	$1.21 million	$1.38 million

Capital Costs Construction Cost GIPOP2 = $3.3 million

Table of Contents

	Page
Introduction	1
Alternatives Investigated	2
Alternative #1 – No Action	3
Alternative #2 – Status Quo	4
Alternative #3 – Status Quo + Nutrient Reduction	5
Alternative 4 – Dam Removal or Lowering Water Level	6
Alternative 5 – Operate Existing GIPOP + Implement Additional Point Source Controls	8
Alternative 6 – Status Quo + Non-Point Source Controls	8
Alternative 7 – Implement Point Source Reductions + 2 GIPOP's	9
Allocation Methods	11
TMDL for Gulf Island Pond	12

Appendix
Tables
BOD5 / TSS / TP Allocations
Allocation Calculations

Figures
Gulf Island Pond TMDL – Summary of Allocation Methods
Weekly Average BOD5 Loads
Monthly Average BOD5 Loads
Monthly Average TSS Loads
Monthly Average TP Loads

Introduction

This study focuses on Gulf Island Pond, which is a large impoundment on the Androscoggin River that extends for 14 miles from Lewiston to Turner. A four-mile segment upstream of Gulf Island dam is on Maine's 303d non-attainment list of bodies of water that do not meet relevant water quality standards. This segment does not meet designated use of aquatic life support because it fails to meet (1.) class C dissolved oxygen criteria and (2.) the designated use of water contact recreation due to yearly occurrence of algae blooms. The Clean Water Act requires that a TMDL (Total Maximum Daily Load) be completed for this water segment. A TMDL is a plan specifying how pollutant inputs will be reduced in order to comply with water quality standards. This is typically determined mathematically with a water quality model. A water quality model was developed by DEP using data collected both historically and in the summer of 2000. The Androscoggin River Modeling Report and Alternative Analysis (June 2002, MDEP, Mitnik, Paul, P.E.) summarizes the modeling analysis and alternatives investigated to improve river water quality to class C standards.

Numerous point sources discharge to the Androscoggin River above Gulf Island Pond and can potentially influence its water quality. Paper mills discharge to the river in Berlin, NH (Nexfor Fraser Paper Inc.), Rumford, ME (Mead Westvaco Corp), and Jay, ME (International Paper Co). Municipal point sources are located in New Hampshire (Berlin and Gorham); and in Maine (Bethel, Rumford-Mexico, and Livermore Falls). The low dilution that is available for point source discharges and the poor capacity provided by the pond to assimilate wastes both result in a difficult situation for maintaining adequate water quality. At drought conditions, 12% of the Androscoggin River flow is composed of treated wastewater. Non-point pollution or pollution related to overland runoff, is comparatively less significant. Sources of non-point source pollution include land use activities related primarily to residential development, silviculture, stormwater runoff, and agriculture.

The Androscoggin River has a long history of continuing efforts by the DEP, the paper mills and others to improve water quality. A low point was reached in the 1960's when it was recognized as one of the ten most polluted rivers nationally. The Clean Water Act, enacted in 1972, resulted in dramatic improvements in water quality. However, with secondary treatment of all point sources, non-attainment of dissolved oxygen (DO) criteria still persisted in more than 50% of the volume of Gulf Island Pond. Studies were undertaken throughout the 1980's to address the continuing non-attainment. Even if all point source discharges were removed, modeling studies predicted that the pond would still be unable to comply with dissolved oxygen criteria, due to a large historical accumulation of waste on the bottom of the pond. As a result, in 1993 an oxygen diffuser was installed five miles up from Gulf Island dam as a way to artificially enhance the dissolved oxygen.

The oxygen diffuser is called the Gulf Island Pond Oxygenation Project (GIPOP). The three paper mills and the electric utility company that operates the hydropower facility at the dam share in the operation and cost of operating GIPOP.

Point sources reductions occurred throughout the late 1980's and 1990's as a result of regulatory requirements and voluntary pollution prevention undertaken by the mills in cooperation with DEP. The combination of oxygen injection and point source reductions brought 80% of the pond volume into compliance with the relevant dissolved oxygen criteria. It was expected that the pond might continue to improve throughout the 1990's, but data collected by DEP show that this has not occurred. Instead algae blooms began to occur more frequently, which further contribute to the oxygen problem.

The recent modeling studies undertaken by DEP from 2001 to 2002 indicate that the algae that settles to the pond bottom are a large contributor (up to 65%) to the sediment accumulation on the bottom of the pond. Hence the algae are responsible for much of the DO non-attainment. Up to 85% of the sediment accumulation can be accounted for by current pollution sources. Historical accumulations of waste are no longer perceived to be a significant factor in the current DO non-attainment. A necessary action for cleanup of Gulf Island Pond should target the elimination of algae blooms. The Androscoggin River Modeling report indicates that point source phosphorus reductions are the most effective way for reducing levels of algae.

The DEP has recent drafted legislation that determines how compliance with dissolved oxygen criteria will measured in riverine impoundments. This legislation proposes that dissolved oxygen will not be measured for compliance in poorly mixed bottom areas of impoundments, areas where mixing is inhibited due to thermal stratification or natural topographic features.

This situation is analogous to lakes where it is often difficult to maintain well-oxygenated water at depth if thermal stratification occurs. Maintaining adequate dissolved oxygen at depth is even more difficult in riverine impoundments, since point source discharges can accumulate and settle out pollutants in the impoundment. In contrast, there is a prohibition in Maine law for point source discharges to lakes or tributary to lakes.

If this law is adopted, dissolved oxygen would not be measured below the thermocline or depth where thermal stratification occurs, typically at a depth of 60 feet. About 1% of the volume of Gulf Island Pond occurs below a volume of 60 feet. The proposed legislation eliminates compliance issues in poorly mixed areas where most abatement alternatives investigated cannot meet DO criteria.

It should be noted that although this report focuses on improvement of water quality to a 4-mile segment of Gulf Island Pond, additional phosphorus and other pollutant reductions will result in large benefits of improved water quality. This would include benefits such as improved oxygen or reduced solids and algae for large areas of the river from New Hampshire to Gulf Island Pond. Dissolved oxygen will also be improved below the pond and, in particular, the Deer Rips impoundment immediately below Gulf Island dam, where DO compliance is marginal.

Alternatives Investigated

The following alternatives and the expected water quality results are discussed in this report.

1. No Action – Allowing additional point source pollutant inputs up to licensed limits thereby maintaining current licensed amounts.
2. Status Quo – License point source BOD/ TSS of primary contributors at actual discharge levels rather than potential (licensed) discharge levels. No requirements for additional point source phosphorus reductions.
3. Status Quo + Nutrient Reductions - License point source BOD/ TSS of primary contributors at actual discharge levels rather than potential (licensed) discharge levels. Require additional point source phosphorus reductions to eliminate algae blooms.
4. Alter or Eliminate Impounded Waters - Dam removal or reduction of dam height.
5. Reduce or Eliminate Point Sources – Investigate additional reductions from #3.
6. Status Quo with Non-point Source Reductions – Investigate additional non-point source reductions from #2.
7. Additional Point Source Reductions and Additional Oxygen Injection – Investigate additional point source reductions from #3 and additional oxygen injection at different locations.

Note that in all the alternatives investigated, with the exception of dam removal, it is assumed that the current oxygen injection will continue. Alternatives 1,2,3,and 6 do not meet class C standards in areas that are poorly mixed and additional areas where adequate mixing occurs. This would require undertaking a Use Attainability Analysis (UAA) (described in next paragraph) for each of these alternatives. Option 4 eliminates poorly mixed areas and the issue of compliance there. Options 5 and 7 would meet DO criteria in all areas except poorly mixed areas. Without the proposed legislation a UAA would be required, but with the proposed legislation a UAA may not be required depending upon the interpretation by EPA of the effect of any change in the law.

A Use Attainability Analysis (UAA) is a structured scientific assessment of the physical, chemical, biological, and economic factors affecting the attainment of designated uses of a water body. A UAA is undertaken in situations, when after considering all available and reasonable options, existing water quality standards are unattainable or not affordable. The evaluation of the cost of all possible alternatives of river cleanup and the water quality that results is necessary to meet the requirements of state and federal law for a UAA. The goal of a UAA is to have the best water quality possible within affordable constraints. The criteria set in class C are the minimum needed to support the fishable and swimmable goals of the Clean Water Act. As a result of a UAA, it might be necessary to establish numerical criteria for dissolved oxygen that are less stringent than existing class C criteria. In the case of Gulf Island Pond, this would result in some loss of aquatic life use. This would be the first time that a UAA would result in a water body not attaining class C water quality standards.

Alternative #1 - No Action

The no action alternative would license point sources as currently licensed. BOD and TSS limits would remain unchanged and no requirements for nutrient reductions would be implemented. GIPOP would continue to inject up to 92000-ppd. oxygen in Gulf Island Pond at Upper Narrows, a constricted area five miles up from the dam.

It should first be stated that the licensed amounts or quantity that point sources could potentially discharge into the Androscoggin River above Gulf Island Pond are typically much more than the actual amounts discharged. For example, licensed amounts for point source discharges of BOD are collectively twice the amount of actual BOD that was discharged from 1998 to 2000. The licensed amount of point source total suspended solids (TSS) are three times the amount of actual TSS that was discharged from 1998 to 2000. Hence water quality in Gulf Island Pond and the Androscoggin River would decline if point source discharges were to discharge at the highest licensed limit.

A modeling analysis for a TMDL must use a condition of worse case water quality as a basis for establishing allowable loads to the receiving water. It can generally be assumed that if water quality is maintained during the worse case conditions, then water quality should be maintained under all circumstances. Hence point source loads are modeled at the higher licensed conditions. The following water quality was predicted in the modeling report for point sources licensed at current conditions, and assuming that GIPOP would be injecting oxygen at the maximum rate of 92,000 PPD:

- Class C dissolved oxygen (DO) criteria would not be met for a length of 38 river miles (including 24 river miles above Gulf Island Pond) and in 72% of the volume of Gulf Island Pond
- The levels of algae would be about 2.4 times the threshold level indicating bloom conditions (threshold level = 8 ppb for chlorophyll-a)

It can be observed that this would result in a major degradation of water quality from current conditions, since the actual discharged amounts already result in DO non-attainment in 4 river miles and 20% of the volume of Gulf Island Pond. This alternative could not be allowed without undertaking a Use Attainability Analysis (UAA). However one of the requirements of a UAA is that, assuming the classification criteria are not attainable within affordable constraints, the best possible water quality must be obtained. Since the actual existing level of treatment has already been demonstrated to be affordable, a UAA could not be used to justify keeping point sources at actual licensed amounts. Hence this option is not feasible.

Alternative #2 - Status Quo (Current Actual Discharge)

To determine the actual levels being discharged by point sources, the modeling report used the treatment facility discharge monitoring reports (DMR's) as reported from 1998 to 2000. A 95% confidence interval of a log-normal distribution was used to define paper mill actual discharge levels. This allows for a buffer for treatment variability that the use of average discharge conditions, for example, would not allow. Since point source municipal discharges of BOD and TSS are relatively insignificant compared to the paper

mill discharges (municipals are 1% to 2 % of the total load for TSS and BOD, respectively) it was presumed that licensed amounts for municipal point sources would not be changed for BOD and TSS in any load reduction strategy. As will be discussed later, the municipal discharges do make a difference when considering phosphorus inputs, and must be considered in any load reduction strategy for phosphorus loads to Gulf Island Pond.

Maintaining BOD and TSS at total actual discharge levels can be accomplished by many different allocation methods. One should consult the final section of this report in which four different allocation methods are presented. The four methods presented are allocations based upon actual current treatment performance, equal treatment performance, equal percent reductions, and equal impact of dissolved oxygen depletion in Gulf Island Pond. The following collective allocation would result for point sources using the status quo alternative:

- Limit municipal BOD/TSS to current licensed levels
- Reduce potential BOD (licensed point source conditions) entering Gulf Island Pond by 46%. This will be implemented by net reductions in the total paper mill BOD from licensed to actual discharge conditions.
- Reduce potential TSS (licensed point source conditions) entering Gulf Island Pond by 64%. This will be implemented by net reductions in the total paper mill TSS from licensed to actual discharge conditions.
- Maintain current GIPOP at maximum oxygen injection rate of 92000 ppd.
- No limit established for point source phosphorus
- Individual allocations of point source BOD and TSS depend upon which allocation method is used (see page 10).

With this plan implemented, the following water quality is predicted in the modeling report:

- Class C dissolved oxygen (DO) criteria would not be met for a length of 4 river miles in Gulf Island Pond and in 20% of the volume of Gulf Island Pond
- The levels of algae would be about 2.1 times the threshold level indicating bloom conditions

Class C water quality standards would not be met under this alternative and a UAA would have to be undertaken. The GIPOP cooperative has proposed the use of a new impoundment DO criterion in which 75% of the volume attains criteria, i.e. 25% of volume is exempted. This alternative would meet the 75% criterion, assuming it was adopted, but the reduction of algae blooms would still have to be addressed. Algae blooms result in non-attainment of narrative criteria of meeting designated uses "in and on the water" in the class C water quality standards.

The DEP could not use impoundment DO criteria that allow 25% of the volume of Gulf Island Pond to be exempt unless demonstrated through a UAA that this is the most

feasible alternative. Reductions of point source total phosphorus would still be necessary.

Alternative #3 - Status Quo + Nutrient Reduction

This alternative would be identical to the previous one discussed with additional reductions of point source phosphorus implemented to reduce algae levels in Gulf Island Pond to below the bloom threshold of 8 ug/l chlorophyll-a. The modeling report indicates that predictions of conditions with no mill discharges but only municipal discharges and natural and non-point sources inputs indicate that algae levels would be right at threshold levels. Hence no phosphorus allocation would be available for the paper mills if municipal discharges of phosphorus are not reduced. This implies that phosphorus reductions will have to be implemented at both municipal and paper mill discharges.

The allocation method for phosphorus is anticipated to be applied differently than BOD and TSS, due to the fact that real reductions from actual discharge levels need to be implemented for phosphorus, rather than reductions from a large buffer being allowed by the difference of allowable or permitted BOD/TSS and actual discharge levels. The modeling report indicates that, collectively, paper mill inputs account for 77% of the total phosphorus entering Gulf Island Pond and the municipal discharges 13% of the total phosphorus entering the pond. The remaining 10% is from non-point and natural sources of pollution. Hence it is likely that mill requirements will be more stringent than municipal requirements. Allocations are discussed in the final section based upon equal treatment according to discharge type (mill or municipal), equal percent reductions and equal impact.

The modeling report indicates that an eventual reduction of 60% of phosphorus entering the pond is needed to meet target levels. It is possible to implement this in steps of a phased TMDL that would require ongoing monitoring, similar to a TMDL being implemented on the Salmon Falls River. In summary, this alternative would require the following:

- Limit municipal BOD/TSS to current licensed levels
- Reduce potential BOD (licensed point source conditions) entering Gulf Island Pond by 46%. This would be implemented by net reductions in the total paper mill BOD from licensed to actual discharge conditions.
- Reduce potential TSS (licensed point source conditions) entering Gulf Island Pond by 64%. This would be implemented by net reductions in the total paper mill TSS from licensed to actual discharge conditions.
- Maintain current GIPOP at maximum oxygen injection rate of 92000 ppd.
- Reduce the total phosphorus entering Gulf Island Pond by 60% through point source tertiary treatment. Since background phosphorus will not change, this requires a 67% reduction in point source phosphorus.
- Individual allocations of point source BOD, TSS, and phosphorus depend upon which allocation method is used (see page 10).

With this plan implemented, the following water quality is predicted in the modeling report:

- Class C dissolved oxygen (DO) criteria would not be met for a length of 4 river miles in Gulf Island Pond and in 9% of the volume of Gulf Island Pond
- The levels of algae would be under the threshold level for bloom conditions.

Class C water quality standards would not be met under this alternative and a UAA would have to be undertaken. The UAA would investigate additional treatment and non-treatment strategies that could be implemented within affordable constraints.

Alternative #4 – Meet Class C Water Quality Standards by Removing Dam or Lowering Water Level

The presence of the impounded waters of Gulf Island Pond can be cited as one of the primary reasons for the DO non-attainment and occurrence of algae blooms. If rivers are allowed to flow freely, they have a large capacity for self-purification. In flowing waters, as waste decays and potentially depletes river dissolved oxygen; oxygen also re-enters the river through surface reaeration. This is accomplished very effectively in flowing waters where riffles or rapids would be occurring, but is very ineffective in sluggish impounded waters. In Gulf Island Pond, the depth near the dam is 70 feet and the poor vertical transfer of surface oxygen to the deeper waters further exacerbates the problem of low DO. It is in these deeper waters (from 30 to 70 feet of depth) where the DO non-attainment primarily occurs.

The presence of the dam also slows down water velocity and increases the time of flow, allowing up to 14 days in the pond for the waste to decay. Sediment is trapped and settles to the pond bottom creating a sediment oxygen demand, which exacerbates the DO depletion in deeper waters. In contrast, faster flowing waters have a large capacity to flush bottom sediment, and time of flow is rapid, allowing little time for waste to biodegrade.

In order for algae blooms to occur, there must be a sufficient residence time in the receiving water. Impounded waters create circumstances more favorable for phytoplankton to grow and thrive.

If dam removal were considered as a possible alternative, the FERC hydropower licensing process would consider not just water quality, but also consideration of all costs and benefits. There are also conditions that are created in impoundments that are not related to water quality that many would consider beneficial. Gulf Island dam is a significant generator of hydropower resulting in an average annual production of 131 kWh. When compared to dams that have already been removed, and had marginal cost-effective power production, Gulf Island dam typically generates 6.5 times the power than

the former Edwards dam on the Kennebec did or 37 times the power than the former Smelt Hill dam on the Presumpscot did.

The removal of the dam would result in new benefit of flowing water opportunities in boating and fishing. However, the lost recreational opportunities of flat-water boating and fishing would be a cost. It is probable that the removal of the dam or even a significant lowering of the water elevation would result in much public debate. The removal of the dam of such a large impoundment would result in much more significant environmental or economic changes than were realized at Edwards or Smelt Hill.

It was estimated by DEP in model run requests by the GIPOP cooperative that a lowering of the dam height by 25 feet could also fix all the current water quality problems. This would eliminate more than 75% of the volume of the pond. This could also result in the subsequent surrender of the Gulf Island dam license to generate power, due to unfavorable economic conditions.

Estimates for purchase and removal of the dam and lost power generation are not readily available. In a UAA undertaken for the Salmon Falls River, it was estimated that the purchase, and removal of three dams that collectively may not be equivalent to the size of Gulf Island dam may cost as much as $20 million. Added on to the dam removal cost are the lost power production and lost recreational opportunities.

With any dam removal, there is the issue of releasing highly organic and / or toxic sediments to the river below the dam. It is unknown at this time what the amount and character of bottom sediments is and whether downstream transport would cause different environmental problems. Dioxin is known to be present in the sediments of Gulf Island Pond.

When the benefits of this option are weighed with the costs, the DEP believes that changing the impoundment size through dam removal or lowering of water level would not be a practical or economically feasible option to improve water quality to acceptable standards.

Alternative #5 – Meet Class C Water Quality Standards by Operating Existing GIPOP and Implementing Additional Point Source Controls

The Androscoggin River Modeling Report and Alternative Analysis (June 2002) investigated a number of point source reductions to meet class C DO criteria. A conclusion of the report is that it is very difficult to improve all of the bottom waters below 30 feet of depth to class C criteria utilizing solely point source reductions. One option of the modeling report reduced point source total phosphorus by 40% and reduced point source BOD and TSS by 90% while still operating the current GIPOP at full capacity. The model predicted that 4% of the pond volume could still be under class C DO criteria with even these drastic reductions. With no point source inputs, the model predicted that compliance of class C DO criteria should result. Hence conditions very close to zero discharge would have to be implemented. In a river with three paper mill

discharges, and seven municipal discharges, it is unlikely that zero discharge could be achieved for all point source discharges even with substantial economic investments in new paper making treatment technologies. A UAA would need to be initiated to determine the best water quality possible within affordable constraints.

Alternative #6 – Meet Class C Water Quality Standards by Implementing Status Quo Alternative and Additional Non-Point Source Controls.

The modeling report gave estimates of both point source and non-point source pollution inputs to Gulf Island Pond. Natural and non-point sources (NPS) of BOD are about 15% of the total load and phosphorus about 10% of the total load. It can be seen that there is very little potential for cleanup of water column BOD and phosphorus utilizing solely non-point source controls.

Non-point sources of pollution are more significant when considered as a source to bottom sediment. The modeling report estimated that natural and non-point pollution sources could account for as much as 40% of the sediment oxygen demand in Gulf Island Pond.
The model runs assume the following:

- Limit municipal BOD/TSS to current licensed levels
- Reduce potential BOD (licensed point source conditions) entering Gulf Island Pond by 46%. This will be implemented by net reductions in the total paper mill BOD from licensed to actual discharge conditions.
- Reduce potential TSS (licensed point source conditions) entering Gulf Island Pond by 64%. This will be implemented by net reductions in the total paper mill TSS from licensed to actual discharge conditions.
- Maintain current GIPOP at maximum oxygen injection rate of 92000 ppd.
- No limit established for point source phosphorus
- Assumption that SOD of natural / NPS origin could be reduced by 50%.

With this plan implemented, the following water quality is predicted by the water quality model

- Class C dissolved oxygen (DO) criteria would not be met for a length of 4 river miles in Gulf Island Pond and in 11% of the volume of Gulf Island Pond
- The levels of algae would be about 2 times the threshold level indicating bloom conditions

It is unlikely that NPS pollution could be reduced to the assumed amounts, but even with this ambitious goal, non-attainment is still expected. This alternative does not meet the objective to meet class C water quality standards everywhere in Gulf Island Pond and can be ruled out as a viable option.

Alternative #7 – Meet Class C Water Quality Standards by Operating Existing GIPOP + 2nd GIPOP + Point Source Reductions

This alternative is the DEP preferred alternative, since it results in the largest volume of the pond meeting water quality standards including all of the volume above the thermocline and appears to be economically feasible. A trial run in the modeling report investigated point source controls together with an additional oxygen injection system (GIPOP2) in-between the current one (GIPOP1) and the dam. This alternative requires the following actions:

- Limit municipal BOD/TSS to current licensed levels
- Reduce potential point source BOD (licensed conditions) entering Gulf Island Pond by 46%. This would be implemented by net reductions in the total paper mill BOD from licensed to actual discharge conditions.
- Reduce potential point source TSS (licensed conditions) entering Gulf Island Pond by 64%. This would be implemented by net reductions in the total paper mill TSS from licensed to actual discharge conditions.
- Reduce point source phosphorus entering Gulf Island Pond by 67% through point source tertiary treatment
- Maintain current GIPOP1 at a reduced oxygen injection rate of 35000 ppd. at 30 foot depth.
- Add an additional oxygen injection system GIPOP2 at Lower Narrows at an injection rate of 70000 ppd. at 50-foot depth.
- Individual allocations of point source BOD, TSS, and phosphorus depend upon which allocation method is used (see page 10).

The proposed injection rate of both oxygen injection systems combined is 105,000 ppd., which is 14% higher than the current rate of injection of GIPOP1 of 92000 ppd. The proposal for two oxygen injection systems is a more efficient way of inputting oxygen into Gulf Island Pond than one injection system.

When considering oxygen injection as an alternative, it is important to pick strategic locations that can most efficiently input the oxygen where it is needed. The location of the current system is a logical location for the first injection site. At Upper Narrows, there is a constriction in the pond, which makes installation across the pond width easier. In addition, it is the approximate location in which DO in the pond first starts falling below criteria. A major deficiency in using this location as the only injection site is the poor transfer of oxygen (injected at a depth of 30 feet) to the deeper waters (depths of 30 to 70 feet) that start occurring 2 miles downstream at Lower Narrows. It is much more effective and efficient to directly inject the oxygen at the deeper depths.

Lower Narrows is a logical second location for the second injection system. There is also a constriction in the pond here making installation across the width easier. Also, it is this location where the bottom of the pond rapidly drops off to deeper waters. Hence the injection system could be put at a depth of 50 feet and in the general vicinity of where the

DO non-attainment is occurring rather than relying totally on the one injection system that is 3 miles upriver and 20 feet above the problem area.

With this plan implemented, the following water quality is predicted in the modeling report:

- Class C dissolved oxygen (DO) criteria could be met in all areas of Gulf Island Pond that are not hydraulically isolated by thermal stratification
- The levels of algae would be under the threshold level for bloom conditions.

The exact cost associated with this alternative depends upon a number of factors such as the allocation method that is chosen and the amount of pollution prevention that is used. Some ballpark costs are provided below assuming that end of pipe treatment is used as the primary method to meet the goals of this alternative. The costs might be reduced if more pollution prevention methods (i.e. changes in paper making technology within the mill) were used.

Summary of Additional Costs

Annual Costs	Cost @ Actual Flow	Cost @ Licensed Flows
TP Treatment to 0.25 ppm for 3 Paper Mills	915,000	1,021,000
TP Treatment to 1.0 ppm for 3 Municipal WWTP's	197,000	263,000
15% Increase of Oxygen Injection	$100,000	
Total	$1.21 million	$1.38 million

Capital Costs
Construction Cost GIPOP2 = $3.3 million

Allocation Methods

Gulf Island Pond is a unique situation where the DO non-attainment in the impoundment is from the combined effects of all the upstream dischargers such that DEP is concerned ultimately with the total pollutant load to the pond, and are less concerned with the allocation of reductions among the dischargers. Therefore, the Department has specified the *net amount (or percent) of pollutants* that needs to be reduced to attain water quality standards, which it will formalize in a Total Maximum Daily Load (TMDL) analysis to be approved by EPA.

While the Department only looked at treatment and oxygen injection, pollutant reductions might also be achievable from process changes at some of the facilities. The Department is not in a position to determine the most economically efficient way to achieve water quality standards at every facility.

Rather than include the allocation of load reductions in the TMDL, DEP proposes that the dischargers negotiate the most economically efficient allocation among themselves

(somewhat like a cap and trade program). For the sake of discussion, DEP offers four different allocation methods.

The four different allocation methods investigated are allocations by actual treatment, equal treatment, equal percentage reductions and equal impact. The allocations by actual treatment only apply to BOD and TSS and not phosphorus. Allocation by equal treatment requires similar facility types to treat to an equal final effluent concentration. Allocation by equal percent reductions reduces BOD and TSS by an equal percentage from licensed amount and total phosphorus by an equal percentage from actual amounts. Allocation due to impact requires each input to have an equivalent input load at the entrance to Gulf Island Pond. In the total phosphorus allocation, all municipal inputs were treated as one input.

In the BOD5 and total suspended solids (TSS) allocations, municipal treatment plants were held constant at current licensed levels, due to their very small contribution to the river (< 2% of total load). Hence for the BOD5 and TSS allocations, licensed reductions were only investigated for the paper mills. The allocations resulted in the load to Gulf Island Pond for TSS and BOD being held to current levels, based upon a 95% CI of three years of discharge monitoring for the paper mills as reported to DEP from 1998 to 2000.

The total phosphorus allocations resulted in allocations for three additional municipal plants (Berlin, Rumford-Mexico, and Livermore Falls) in addition to the three paper mills. These three municipal plants were judged to have significant phosphorus contributions to algae blooms in Gulf Island Pond. Allocation for the smaller municipal plants (Gorham, Bethel, Rumford Point, and North Jay) were held at constant discharge levels due to their small contribution to algae blooms in the pond. Since actual discharge levels for total phosphorus of point sources results in algae blooms in Gulf Island Pond, this was not included as a viable allocation method.

The actual total point source TMDL allocation will vary depending upon which allocation method is chosen. This is due to the consideration of what location the majority of the pollutants are inputted. For example, if more BOD is inputted in Berlin rather than Jay, the river as a whole can withstand more BOD, due to the large amount of BOD that is assimilated from Berlin to Gulf Island Pond (77% at low flow conditions). The allocation method based upon impact to water quality resulted in the largest amount of point source pollutant load allocation, and the allocation method based upon equal percentage reductions resulted in the lowest point source pollutant load allocation.

Finally it should be mentioned that there is a aquatic life non-attainment issue in the Livermore Falls impoundment related to International Paper's discharge of TSS. This may result in TSS allocations for IP that are more stringent than that needed to maintain adequate water quality in Gulf Island Pond.

TMDL for Gulf Island Pond

The individual TMDL for each point source depends upon the allocation method being utilized. A summary of the total TMDL for Gulf Island Pond as a whole is as follows:

- BOD – Limit BOD entering the pond to no greater than current levels. This requires a net reduction in the total current licensed levels from the paper mills of 46% and 40% for a monthly and weekly average, respectively.
- TSS - Limit TSS entering the pond to no greater than current levels. This requires a net reduction in current licensed levels from the paper mills of 64% for a monthly average.
- Total Phosphorus – Reduce TP entering the pond by 60%. This requires a net reduction of the total point source TP inputs of 67%.
- Non-point Sources of BOD / TSS / TP – Limit to not greater than current levels
- Oxygen Injection – Require oxygen injection of GIPOP1 = 35000 ppd. and GIPOP2 = 70000 ppd., respectively, at Upper and Lower Narrows. This is a 14% increase from current oxygen injection but requires an additional injection point.

The final allocation for each point source is not specified in this report. The DEP is encouraging point source dischargers to determine the most economic way of achieving water quality standards through mutual agreement. This might involve an innovative system for trading pollution credits among the eight dischargers. As a starting point, DEP has offered four different methods for allocating point source inputs (actual treatment, equal treatment, equal % reductions, and receiving water impact) were investigated.

Assuming passage of the proposed legislation, a TMDL could be submitted to EPA this spring, which is not specific to each point source but specifies the total pollutant load reductions needed to meet water quality standards. The final pollutant loads for each discharge can be established during waste discharge licensing for each discharger.

Appendix